Cost Measurement in Laparoscopic Surgery: Results from an Activity-Based Costing Application

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Cost measurement in laparoscopic surgery: results from an activity-based costing application

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Abstract Activity Based Costing (ABC) techniques are designed to support advanced cost analysis in different organizations. Centred on organization activities and processes, it provides more accurate cost information on cost objects using appropriate cost drivers and constitutes a powerful costing model to improve efficiency and effectiveness in delivering products and services.
ABC can be successfully applied also in Health Care organizations, where the patient is the main "object" of the activities performed. In addition, in can be fruitfully used in costing the resource consumption of new medical technology devices or surgery processes to assess their economic impact on health care costs. The purpose of this paper is to describe an Activity based costing model designed to measure and control resources consumption and cost when a new technology is applied in health care processes. An ABC model has been defined in relation to laparoscopic technologies applied to surgical cases, designing a health care "activity hierarchy" based on the processes of a specific local unit organization. The output of the application has been a full cost of laparoscopic surgery to be compared with the correspondent DRG current value.
As a further result, the paper shows how the ABC model is able to generate different cost figures referred to activity levels or aggregations able to support decision making especially when the introduction of a new surgical technology has to be economically assessed. Propositions are finally made to generate discussion about the effectiveness of the existing cost accounting systems in the health care organizations and on the need for the wider diffusion of ABC techniques in this service sector.

Key words: Activity-Based Costing, Economic assessment of surgery techniques

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1 Introduction

Innovation technology development in Health care requires great attention to the evaluation of the major impacts that its implementation can create considering its multiple dimensions.

The economic dimension is one of the aforesaid dimensions, if we consider the magnitude of the health care expenditure in modern economic systems.

In other words, the introduction of new technologies in health care organizations takes into consideration the economic impact that this introduction can generate also in relation to the economic sustainability by the social and economic system as a whole.The paper comes from the collaboration concerning a research project[1] developed by the EndoCAS Centre of the University of Pisa, whose mission is to play a key role in the Computer Assisted Surgery (CAS) for endoscopic surgery applications both at national and international level.

Among the main activities of the Centre, it is possible to identify some support activities of economic and financial validation (Technological and Economical Validation Activities). These activities are oriented both to effectiveness analysis and cost and benefit analysis on the use of CAS technologies, and to support, from an economic perspective, the sponsorship of the diffusion and large scale use of these particular systems.

In major detail, this paper is the outcome of an in depth research activity and discussions with the purpose of designing "a model" which could be useful to support the economic analysis for surgical operations in which laparoscopic technologies and techniques are adopted. Specifically, in its first version, the research has been applied to surgical operations performed in the Surgical Departments of hospitals and health care organizations belonging to the Regione Toscana (Regional Body - Tuscany).

In order to carry out the aforesaid financial and economic validation activities, cost information is needed. Cost information is usually accounted in the health care organizations' cost accounting systems and management control systems. The effort in our research is to place side by side the technology innovation in surgical services and operations and methodological innovation in the correlated cost measurement.

[1] A research project financed by the MIUR (Education and University Ministry) by Ministerial Act of October 17th 2003, prot. n. 193/2003 "Cofinanziamento Centri di Eccellenza Bando 2001", Project Unit n. 5: "Economic Validation Models for new technologies in surgery".

Methodological innovation in cost measurement requires advanced costing techniques oriented to a more accurate measurement of the resources consumption.

Results from an experimental study conducted in a Tuscan Health Care Organization demonstrate the usefulness of the monitoring resource consumption in relation to these advanced technologies in surgical and medical fields; indeed, starting from this point it is possible to draw out multiple information, which is useful for different purposes.

Furthermore, the designed model can be usefully extended to other cost objects in the medical field. Distinctively, an Activity-Based Costing model has been developed on the basis of the "Activity Hierarchy" approach applied to health care activities, which provides the means to generate various cost figures composing the total final cost, functional to a variety of decision purposes.

The paper is organized as follow: it begins by the review of the main contributions to experimental researches on the Activity Based Costing in action in the health care field and then it refers to the important role played by cost information in studying the impact of new laparoscopic surgical techniques. At the end, the core phases of the ABC model design are described together with the results of its application in the field.

2 Activity Based Costing: issues and implementations in Healthcare

Issues related to Activity Based Costing in healthcare have been studied for years in relation to questions such as its potential application and results in several levels and settings of healthcare organizational environment.

Since the nineties the main aspects related to this costing system have been principally three: changes in healthcare managerial context, the effectiveness of more correct cost information in healthcare, the potential managerial effect of an activity based costing system.

Regarding the first aspect, the changes occurred in costs structure and in the manner of supplying healthcare services have emphasized the importance of indirect costs. It is also due to the ever-growing use of health technology to support diagnosis and care processes alongside the need to govern operative flows thanks to a process representation which shows the different stages of service supply. Service supply is not only related to hospital health care activities (Ruta, 1990; Ruta e Toscano,1992; Lega, 1997) but also to the relationship between hospital and territorial services (for example patient pathways). Furthermore regarding territorial services, a good analysis regarding efficiency and effectiveness control can be performed only by applying activity based costing models (Miolo and Nuti, 2004).

Concerning the second aspect, the use of drivers which can explain the relationship between used resources (indirect) and cost object, allows us to get accurate cost information and more reliable cost estimation compared to the one we get by using traditional accounting systems. ABC is often applied to particular clinical pathways with the following goals: i) to represent the process and show how it has been achieved; ii) to have a benchmarking concerning price; iii) to underline relationship between clinical output and resources used. Two interesting Italian cases in literature are: the Ferrara District experimentation, in which an analysis of costs of patients who underwent home oxygen therapy was carried out to plan operational activities (Vagnoni and Potena, 2003) and the case of immuno-haematology and transfusion system of Parma hospital (Casati, 1999: pp 223 and followings). Several ABC experimentations have been carried out to determine the cost of intermediate services of laboratory output (Filatondi e Pasdera, 2001; Lievens et al., 2003): in this cases ABC is able to show the different resource consumption when there are several levels of complex activities linked to different outputs. So this system can provide an accurate evaluation regarding the efficiency in the use of resources, useful for both solving pricing issues and evaluating healthcare services performance .

The third aspect is linked to the managerial effects considering that the analysis of activities and processes can support decisions oriented to continuous improvement (integration, reducing time and duplications, "bottleneck" management, quality improvement, benchmarking: Lega, 1997). Some experimentation of this kind has been performed in a non-hospital field: for example, in the Local Health Authority of Prato. Here an analysis of the costs of a pathway (ACPC) (in the field of "Patient admission and taking over" in the SERT Department) was performed to know afforded costs and to identify a strategy to achieve an improvement in cares value. The identification of the costs of the single process steps and benchmarking between the perceived value of the single steps by the operators and calculated costs made it possible to understand what should be changed because it costs too much compared to its value (Vannucci et al, 2001)[2].

Experimentations of ABC concerning the hospital structure as a whole are limited: they would introduce a cross-sectional point of view in all the organization but at the same time would need a suitable information system and strong involvement of all the staff. We can recall the international case of the Transfusion Service of the Healthcare Services of the United Kingdom: this case did not only have the simple objective of trying to find a way of reducing costs but it strongly wanted to obtain the necessary coordination among processes to optimize the use of capital whilst maintaining a strong focus on organization. In this case the staff made strong resistance to the change; in fact, in 1993 this initiative came to life but experimentation only began in 2000 after two unsuccessful attempts (Arnaboldi and Lapsley, 2005).

Potential opportunities (and limits) of ABC are based on the above considerations. However, nowadays it is less difficult to apply this model in the Italian healthcare setting because, after the introduction of accrual accounting, several years ago, most of the difficulties in using accounting data for management purposes in healthcare companies have been resolved.

3 The cost of laparoscopic surgery as a field of experimentation of ABC: the meaning of information

Modern surgery tries to minimize the inconveniences as a result of the operation and to maximize the success of the therapy, so it is becoming less invasive with the target to reduce pain deriving from the operation. Laparoscopy is an abdominal and pelvic surgical technology that makes it possible to carry out an operation only by making small incisions (about 1 cm each) using specific instrumentation, while traditional surgery requires a wide surgical incision on the abdomen. In consideration of this fact laparoscopy technology is considered less invasive than traditional surgery.

[2] See also "Health care needs of the diabetic patient", winner at FORUM -PA 2004 in http://www.forumpa.net/forumpa2004/sanita/cdrom/home/progetto/29 4.html

In general, the impact of new technologies in surgery can be analyzed considering several issues: clinical effectiveness, quality of the patient's life, the organization of work and economic issues. Therefore we cannot univocally classify the innovative aspects of laparoscopy because they can influence the outputs from different points of view: for example, the reduction of hospitalization can generate both numerous changes on organizational aspects and a reduction of costs, while a higher effectiveness of an operation, due to a reduction in complications rate, can generate both an improvement in the quality of life and a reduction of costs linked to the treatments due to complications.

Exhibit 1 shows the principal effects regarding clinical and economic aspects:

Exhibit 1 Impact of Laparoscopic Technology

Impact on expense		**Key elements**		**Impact on cost**	
Possible increase in the expense	Increase on the demand of services	Higher effectiveness and safety	Lower invasive character Lower time of operation Lower number of complications Higher effectiveness Reduction of pain Lower hospitalization Lower convalescence Esthetical advantages	Higher cost of instrumentation Lower cost for hospitalization Lower cost of convalescence Lower cost for complication and relapse	Possible reduction of direct costs Possible reduction of indirect costs

In particular, more recently, the economic issue is becoming of increasing interest.

In the last years several studies regarding the cost of laparoscopic surgeries have been performed and all the studies have concluded that even if these techniques seem more expensive than others, we can equally get a reduction in costs because they are more effective (because of the low relapse rate) and have a limited postoperative hospitalization at the end.

Some studies only consider the direct resources (such as personnel, instrumentation and drugs), other ones also consider deeper issues such as the "social cost" [3]. For example

[3] Studies cited are: The study of Italian Society of Urology edited by on line magazine "Clic Medicina" (De Rose, 2002), the study carried out in Piedimonte Matese Hospital (Romano, 2002), study of Assobiomedica (Mazzei, 2002), the study of the Department of General Surgery,

the case study of the Piedimonte Matese Hospital (Romano, 2002) has benchmarked direct costs of the drugs, the workforce and used materials for the hysterectomy treatment both in the case of laparoscopic and the traditional technique: it shows that the two kinds of technologies amount to about the same cost because, even if laparoscopic instruments are more expensive than traditional ones (€ 293.99 for laparoscopy and only the low cost of instrument sterilization for the traditional technology) we can save on the cost of personnel (because laparoscopic surgery has a more limited duration) and of the drugs (the total saving is € 138 for personnel and € 160 for drugs). Furthermore if we also consider the costs of hospitalization (two days for laparoscopic technologies and four days for traditional ones) we can observe a saving of € 800 for laparoscopic surgery.

The two case studies developed in Holland and United Kingdom have analyzed some representative samples using a multidimensional approach: in fact they have studied both traditional costs elements and social costs (such as a low number of lost working days, low hospitalization, less scars and a low number of convalescence days) and long-term benefits (analyzed through some questionnaires that patients have filled in after the operation). Some of these benefits are a minor percentage of pain in the days after the operation (with advantages in terms of quality of life, on work and social issues in general) but above all they have a low relapse rate, pain and infection in the following months (Drummond, Stoddart e Torrance, 1992).

These argumentations suggest that the use of instruments orientated to activities, such as ABC, makes it possible to understand the aspect related to the processes (and through this to understand questions related to economic issues, social aspects and quality of life) and to the costs in the long term, while if we limit our analysis to a limited number of elements we can only say that these kinds of surgeries are more expensive than others.

4 The Activity-Based Costing Model developed for the study

The generation of a "model" is one of the main phases in applying an ABC system. Activities, cost drivers, final cost objects and logic relationships among various components of the systems can be defined during this phase. In the *ABC modelling* evolution, the "Activity Hierarchy" approach has progressively become widespread because it allows for the definition of different cost aggregations which represent diverse "moduli" that are functional to decisional and cognitive aims. One of the main contributions deriving from cost analysis based on activities is the innovative cost accumulation in relation to their belonging to activities which can be allocated to different "referability levels" as regards to the final output [4].

University Hospital and of the Department of Epidemiology & Public Health, Ultrecht Univerity (Liem, 1997).

[4] In its primary concept, Cooper e Kaplan (1991; 1999) proposed an "activity hierarchy" referable to the production process in manufacturing firms which was articulated in the following levels:
- *unit-level activities*;
- *batch-level activities*;
- *product-sustaining activities*;
- *facility-sustaining activities.*

Depending on the activity it is possible to identify the associated costs:

This distinction among activities and costs is useful in obtaining a more correct specification of drivers. Different drivers reflecting the implied behaviour of the "activity demand" of the product (cost object) have to be employed for each activity level. Therefore, the activity driver's definition for allocating activity costs to the products/services should be made on a cost rise level basis. A development of an ABC system requires the consideration of the change attended in the cost structure in modern organizations; in more detail, the cost structure is characterized by a rise in the non-production indirect costs (marketing, administration, research and development) compared with the costs strictly connected to production of goods or services.

Activity Hierarchy identification clearly shows the differences between traditional cost accounting systems and ABC systems; while in the former indirect and overhead costs are applied to production only on the basis identified at unit level (*volume-related),* in ABC systems other levels and new drivers are identified, drivers which explain resources consumption through dynamics not only connected to output volumes (Cinquini, 2004).

According to the fact that the principal aim of our ABC Model is to measure the cost of a laparoscopic *operation*, its design and development have been carried out according to the "Activity Hierarchy" methodological principle and to the operative features of the specific healthcare organization in which the study has been performed, that is the ASL 12-Versilia of Tuscany Region.

Therefore, coherently with our target to measure the ABC cost of laparoscopic operations, it has been necessary to define a costing model based on the ABC principles to determine a resource consumption model, starting from the cost accounting system used by our specific organization (AUSL 12). In the following sections the cost model developed for the purposes of our research will be described in depth. In fact, some features of the model can also constitute a general framework for any ABC model that could be applied in the healthcare organizations, especially when new technologies are applied. Later on, results from the ABC model application to the AUSL 12 will be illustrated and discussed.

Unit-level costs referring to activities at single unit levels (e.g. labour costs, materials, equipment depreciation, power); at product/service level all the costs are referred to resources (production factors) and not to activities, in fact a change in the resource consumption is determined by changes in the output volume;

Batch level costs, referred to activities carried out on the production batch (e.g. *setup*, transfers, material and component procurement, quality control;

Product-sustaining costs, that is the product line which embraces activities carried out to define in the planning phase, the functional, aesthetic, production features both in the pre-production phase and in the production one (e.g. project changes in order to satisfy specific requirements of a customer);

Facility-sustaining costs are overhead costs deriving from support activities to the factory (e.g. plant management, electric lighting, heating etc.). An extension of the analysis above the boundaries of the production area makes it possible to enlarge the cost hierarchy in order to include: Costs associated to administration personnel, general maintenance, security among overhead costs (*business-sustaining* or *facility-sustaining activities);* Costs deriving from support activities which allow the firm to give a sales service to a single customer but are independent from the products volume and mix (customer care, delivery, special requests, technical support to the customer). These activities can be identified as *customer-sustaining activities* and the connected costs are really important in customer profitability analysis.

4.1. The "Activity Hierarchy" in hospitals and health care organizations

A particular feature of the ABC system is cost drivers identification both in the phase of assignment of resource costs to activities (*resource drivers*) and in the assignment phase of activity costs to final cost objects (*activity drivers*). An innovative aspect of this system is to identify, to this purpose, different activity pools (levels) with a different "referability" level to the cost object as well as diverse cost variability models compared to the output.

In this way, the identification of cost drivers for the activities can be achieved in a more correct manner. Cost drivers are chosen in relation to the cause that has generated the cost; an activity hierarchy for different cost objects is the output of this phase (Cooper, Kaplan, 1991, 1999; Ittner, Larcker, Randal, 1997).

In the case of a health care organization, the hierarchy reflects the process or the (non continuous) clinical pathway that the patient can follow inside the organization, putting together the activities according to the order connected to the cost "traceability". It is the patient that is "charged" with the costs associated to the activities that he/she activates during his/her clinical path.

Consequently, in the development of our ABC model, the phase of activities and process identification has been made simultaneously with the phase of pooling the same activities in pools which express different "hierarchical levels". Since the target of the ABC model was to measure a more accurate cost for a patient in hospital (a patient who undergoes or not a surgical operation), it has been possible to categorize the following hierarchy of costs and activities:

- *Activities (costs) at "patient" level*
- *Activities (costs) at "stay in hospital day" level*
- *Activities (costs) at "(surgical) operation" level*
- *Activities (costs) at "department" level*
- *Activities (costs) at "general support" level*

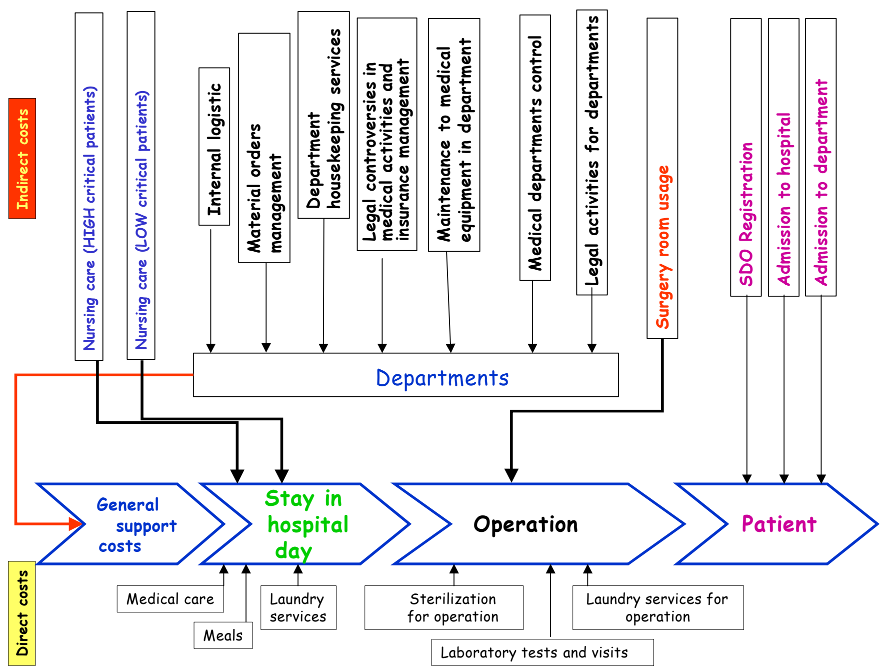
For each level, activities and connected costs are described in the following table (Table 2) and their connections are showed in Exhibit 2.

Table 1 Activities in the hierarchical model

Hierarchy levels	**Activities/Costs**
Patient level	Admission to department
	Admission to hospital
	SDO Registration (SDO = Hospital Discharging Card)
Stay in hospital day level	Nursing care (depending on how sever the patient's condition is)
	Medical care
	Meals
	Laundry service
Operation level	Surgery room usage
	Surgical process
	Laundry service for operation
	Sterilization for operation
	Laboratory tests cost and physician visits
Department level	Internal Logistic
	Material orders management

	Department Housekeeping services
	Legal controversies in medical activities and insurance management
	Maintenance to medical equipment
	Medical Department controls
	Legal activities for departments
General support level	Human Resources management
	Supplies and procurement management
	Reporting management
	Budget management

Exhibit 2 Connections in the hierarchical model



For some of the levels, specific cost of services has been categorized: for example, at "*stay in hospital day*" level, there are some direct costs of services related to meals and laundry services, while at the "*operation process level*" direct costs are linked to laundry services for operation, sterilization, laboratory tests and physician visits costs.

These are "direct costs of level" connected to the outputs from the organization units (internal and external to the hospital organization). In particular, costs at "patient level" incur only when the patient goes into the hospital and the department for hos pitalization. They are costs, which are incurred for each patient only once for each hospitalization.

Costs at "*stay in hospital day level*" are sustained when the patient remains in hospital, each day for the period of hospitalization. The longer the hospi talization period (expressed in stay in hospital days) the more the costs accumulated by the patient will be.

If the patient undergoes an operation, other costs will be incurred related to the surgery room usage and to the single activities regarding the operation process strictu sensu, as will be further dealt with in the following paragraph.

Direct costs for this level are laundry costs, sterilization costs for the operation and laboratory tests and costs for the physician visits, which the patient undergoes in preparation for the operation. The "non continuous and personalized" feature of the process for each patient in hospital requires activities and levels to be modulated. The "*stay in hospital day*" costs rise when days of hospitalization for the single patient increase, while operation costs have features, which depend on the kind of operation that the patient undergoes, from its complexity and, so, from the "operation process".

At the end, the model can be completed with costs of support activities both at department level and at hospital level (*department level* and *general support level*). Activities at these levels are aimed at satisfying the need to measure a "full cost" per patient (especially in the case of a patient who undergoes a surgical operation). The recharging of the cost, which is typical in applying an *absorption costing method*, according with the cause and effect rule of allocation, provides the determination of a share of overhead indirect costs (department and hospital) per single patient.

4.2. Activities identification and process analysis: the surgical operation process

Literature roughly points out two methods of process identification and analysis of the connected activities which are useful in applying an ABC system (Davenport 1993; Brimson, Antos, 1994; Berchi Fontanazza, 1991; Ostinelli, 1995):

- The first method starts from the analysis of specific processes, which have to be exploded in their main activities;
- The second method starts from identifying activities carried out in organizational units, pooling afterwards these activities in order to rebuild the joined processes.

Difficulties in putting the first criteria into operation in organizations structured in functional areas, sometimes conduct operators to endow the second one. The process analysis collides with the difficulty in locating interlocutors who are able to explain, in an exhaustive manner, activities that form the process, indicating resource absorption and conditions of unrolling. It is easier to make out "what is really done", starting from the working organization and going on to the process of rebuilding.

In the activities selection phase it is important to take into account that:

Activities have to be relevant, that is they have to absorb a considerable split of resources;

Activities have to be significant, that is they have to be formed by a chain of actions with an unambiguous and identifiable output;

Activities have to be marked, as much as possible, by a unique activity driver; in other words a parameter must exist that puts a linkage between activity costs and cost objects that require its running.

A process can be built using one or more of the following methods in order to identify the relevant activities:

Direct measurement from people who carry out activities, through periodic reports in which time dedicated to each activity can be obtained;

External monitoring: in this case it is the ABC operator who follows, for a suitable period of time what people do, determines the importance of each activity and its relevance for the analysis;

Measurement of the relevance of the hours dedicated to each activity : it is not a direct measurement but a measure of the percentage of hours dedicated to each activity in a reference period (relevance is determined by multiplying the period of running each activity by each relative frequency);

Subjective estimate: in this case each person will be asked, through interviews, to express a percentage estimate of the average time dedicated to each activity.

The core of our work has been the analysis of the *surgical operation process*: in our research this process has been defined by direct interviews to the personnel employed in medical and surgical activities and through direct observation of some of the main actions representing the detail of these surgical operation process activities.

In accordance with the analytical or synthetic level required by the ABC application, the result of the analysis wasthe identification of the following activities (Exhibit 3 and Table 2).

Exhibit 3 – Activity details of the Surgical Process

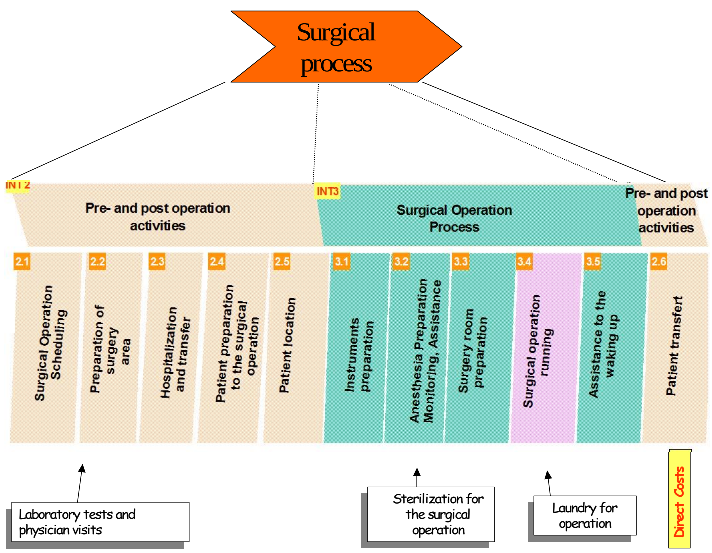


Table 2 Activity description of the Surgical Process

		Activity description		

Pre and post operation activities	Surgical operation scheduling	Patient meets the surgeon in order to schedule the operation		
	Preparation of surgical area	All the actions needed to create the right conditions for the surgery room to be functional for the operation (various controls, starting test)		
	Hospitalization and transfer (to the surgical area)	Patient is transferred from the surgery department to the surgery room area		
	Patient preparation for the surgical operation	Patient is transferred to the pre-room for the documents check; patient is prepared for Anaesthesia and surgery room is prepared with all the necessary material.		Direct costs
	Patient location	Patient is transferred to surgery room and is located		Laboratory tests and physician visits
	Patient transfer	(At the end of the operation) Patient is transferred in the pre-room and then goes back to the hospital ward		Sterilization for the operation
Surgical operation Process*	* In the surgery room.			Laundry and washing for operation
	Instrument preparation	The instrument holder washes and prepares the instruments on the table, then clothes the surgeon		
	Anaesthesia Preparation and Monitoring	The drip feed is connected, anaesthesia is induced, the patient is intubated, the whole operation is monitored		
	Surgery room preparation	The patient is disinfected, the clothes are put in place, the video cameras are covered and the power lines of the equipment are plugged in		
	Surgical operation running	The surgical operation is performed		
	Assistance to the waking up	The patient is assisted until he/she reawakens		

4.3. Cost objects, activity drivers and cost configurations

Once the activities have been located, a critical step is the selection of appropriate drivers to share the cost of the activities between the cost objects (*activity drivers*). The activity drivers have been determined on the basis of the different objects which cost h as been calculated.

In this respect, reliability and simplicity do not always go hand in hand (Cooper et al., 1992). Since an activity driver can be defined as a "determinant of the demand for activity" by the cost objects, this demand can be given in terms of intensity, duration or frequency. This is why a distinction can be made between the following drivers, which have an increasing degree of accuracy:

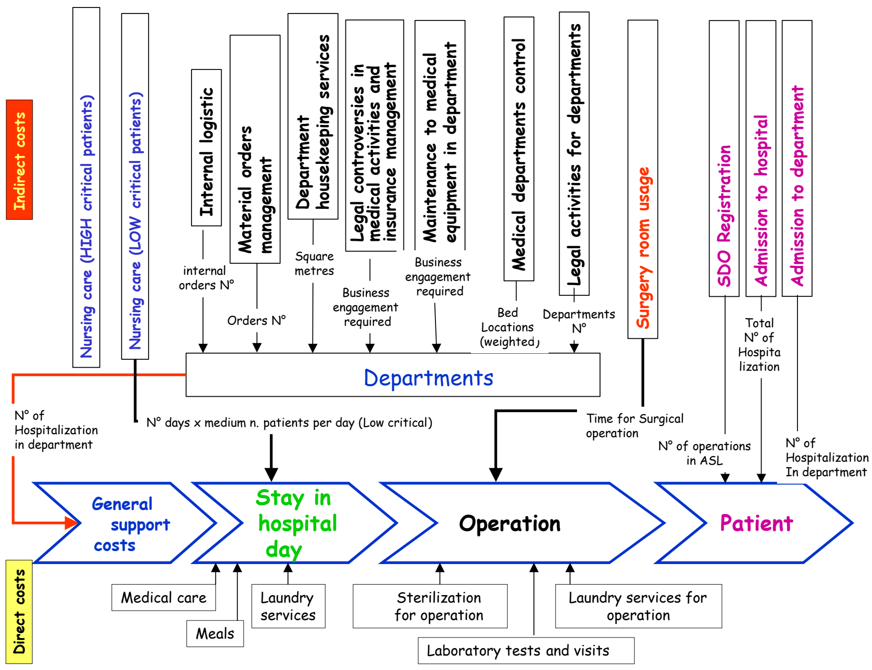
· *Transaction drivers*: these parameters indicate the frequency of a phenomenon and therefore they allocate the costs to a given cost object according to the repetition of a benchmark activity over time. Such drivers are the simplest and cheapest to locate;

· *Duration drivers*: they are used to indicate the duration of a phenomenon and therefore they allocate costs according to the duration of the activity for a given cost object;

· *Intensity drivers*: they indicate a further level of detail, because they also reflect the quality of the resources spent in a given activity.

The drivers used in our work are based on the categories that have been identified by literature (Kaplan, Cooper, 1998). *Transaction drivers* are used for instance to allocate the costs of the activities concerning supplies (number of orders). *Duration drivers* have been used to allocate costs to the activities concerning the use of the surgical unit (average time needed to carry out a surgical operation). In these cases, the use of a frequency driver would have generated distortions, because, since it would determine the average cost for the use of the surgical unit per surgical operation, it would have failed to reflect its complexity (which affects instead the duration of the use of the surgical unit). Finally, *intensity drivers* have been used for the activities concerning the assistance of the patient, which requires a qualification of the type of assistance, since it changes with the severity and how critically ill the patient is. In particular, a driver has been selected which makes a weighed calculation of the duration of the patient's hospitalisation and the allocation of the medical staff of the department involved in the assistance of such patient (Exhibit 4).

Exhibit 4 Activity drivers of the ABC Model



The cost objects follow the rationale of the selected hierarchy of activitie s. They actually consist of units or intermediate aggregations that can be combined with each other to calculate the cost of the patient within the facility. From this perspective, several objects (intermediate and final) have been located which can act as benchmark costs:

- *Daily hospitalisation*
- *Patient*
- *Surgical operation*

At any rate, the entire process rotates around the patient who is admitted to the health-care facility, is taken over, remains in the facility throughout the hospitalisation period and if needed undergoes the surgical operation. The modular character of the model, in which different hierarchical levels and different cost objects are located, can be used to calculate some "cost configurations" [5] with different cognitive and informative purposes for health management. In particular, the following cost configurations have been located:

- *Cost for taking over the patient*: it covers all the costs of direct activities for managing the admission of the patient into the facility and the patient leavi ng the facility when discharged (in the industrial jargon, this would be called the patient's input and output logistics for those activities that are paid for by the business).
- *Cost of the in-patient*: in addition to the costs for taking over the patient (previous configuration), it also covers all the costs associated with the management of the

[5] Cost configuration is determined by the progressive aggregation of cost elements, such as to generate significant information to support the dec ision-making process.

patient's hospitalisation in the hospital or health-care facility, taking into account the duration of such hospitalisation.

- *Cost of the operated patient*: in other words, the cost incurred to manage the patient who undergoes surgery or other treatments. To calculate this cost, the cost of the in-patient is added to the costs associated with the surgical operation and the use of the surgical unit.
- *Overall cost of the patient:* To calculate this cost, the cost of the in-patient is added to the costs associated with any indirect activity (i.e. activities in support of the department and facility);
- *Overall cost of the operated patient*: To calculate this cost, the cost of the operated patient is added to the costs of the indirect activities of the department and facility. This configuration could provide useful information for determining a reasonable rate, especially in the event of extremely innovative operations or operations that have no specific Drg;

Table 3 Cost Configurations

	SDO registration activities;				
+	Hospital admission activities;				
+	Department admission activities				
=	***Cost for taking over the patient***				
+	Nursing assistance activities				
+	Meals and laundry		Cost of hospitalisation		
+	Medical care				
=	***Cost of the in- patient***	+	Costs for supporting the department and facility	=	***Overall cost of the patient***
+	Activities related to the use of the surgical unit				
+	Surgery process costs (including direct costs)				
=	***Cost of the operated patient***	+	Costs for supporting the department and facility	=	***Overall cost of the operated patient***

In our analysis, the process was considered only until the time the patient leaves the facility when discharged. In fact such process could be part of a broader process, in which one could monitor what happens to the patient once the patient is out of the health-care facility and the ensuing costs. The patient could incur costs that can be partly borne by the patient and part by the National Health Service. In this case the perspective becomes wider and encompasses a social outlook on the cost of health.

5 Application of the model for the calculation of laparoscopic surgical operation

The main objective of this study has been to cost laparoscopic surgery by the using the Activity Based Costing model we previously described. We have chosen the cholecystitis treatment surgery because it is, in terms of number, the most frequently carried out by the LHA Surgical department in the experimental setting. In fact compared to the total 383 laparoscopic operations, 285 of these were for cholecystitis treatment (without complications). The others were related to several kinds of operations characterized by a limited number (one or two operations per year). Moreover, focus on this kind of surgery has allowed us to take advantage of a large amount of available data which the hospital had already collected, and in turn results are more significant because high numbers of treated cases can imply a stabilization of the surgeon's experience curve.

5.1 Resource drivers choice and quantification for valorisation of activities

In this case study activity individualization and valorisation has allowed us to analyze in depth the organization structure. This has generated a hybrid system composed of activities and cost centres (Exhibit 2)[6]. Resources that cannot be directly traced were allocated using a Resource – Activities Matrix: for each activity (characterized by an alphanumeric code built by an activity hierarchy level code and by a progressive number) it indicates the department where the activity is carried out (the department also carries out other activities) and the necessary driver to individuate how much department resources are absorbed by the activity in question (resource driver).

Table 4 Example of Activities and Resources Matrix

			Resource Drivers				
Activity Code	Activity	Department	Personnel	Supplies office	Services	Licences	Machinery
DS 7	Management of orders for consumption materials and instrumentation	Purchases	Number of workers	Same ratio used for personnel	Same ratio used for personnel	Same ratio used for personnel	Same ratio used for personnel
DS 8	SDO Registration	Head office	All costs of the office dealing with SDO registration	All costs of the office dealing with SDO registration	All costs of the office dealing with SDO registration	All costs of the office dealing with SDO registration	All costs of the office dealing with SDO registration
DS 10	Health care monitoring in the departments	Head office	Commitment percentage	Commitment percentage	Commitment percentage	Commitment percentage	Commitment percentage

[6] About hybrid system see Marelli, 2004.

A glossary of activities and departments has been defined to build a model that could be applied to different situations. In every activity human resource is the most important work, so the valorisation process is driven by this resource especially regarding support and administrative activities. So when we could not have the information we ne eded to estimate theconsumption of a certain resource, we estimated it as proportional to the time that personnel spent in carrying out activities.

The time spent by personnel was usually determined by asking people to estimate the percentage of time on a certain activity (in respect to their total work engagement). Sometimes we made a direct measure of the time needed to perform an activity. Moreover when it was possible we evaluated resource consumption exactly considering the actual consumption (for exa mple materials used for surgical room cleaning).

Nursing represents an interesting example: in this case we pinpointed two kinds of care intensity based on patient's clinical situation: "critical patient" nursing and "non critical" patient nursing each re garding the Surgical Department. In fact nursing is characterized by a different diligence (based on patient's clinical situation) in terms of time spent and activity complexity.

In fact even if critical patients are less than non critical patients they ab sorb a higher volume of resources. In alternative we could simply use as an activity driver the number of patients but in this way we could only determine an average patient nursing cost [7].

Summing up, in this model we considered two principal activity cost measurement methodology:

Activities costed using resource drivers: these activities are developed inside the departments. They are related to these levels: the Surgical Department, Stay in Hospital day, Patient and General Support (even if activities of these levels are considered in the model they are not allocated in the ABC pilotal implementation here) and of Surgery level (only for activity "surgery room use"). The Resource -Activities Matrix was the tool to manage these costs; it shows the content an d the drivers we have to use in allocating costs. In this phase it is very important that people try to estimate a commitment percentage, which they spend on any considered activity. Once we gain this information we can monetize the activity by doing a sim ple sum of the resources involved. In this phase, to obtain usable information the complete participation of the personnel is essential.

Activities costed in a direct way: They are principally "before and after surgery activities" and "surgery activities" located in the *surgery level*. They are monetized in a direct way by considering:

- *Man hours* and personnel cost per hour
- *Material consumption* and their specific cost
- *Average depreciation of machineries and instruments*: in this case it has been simpler to compute an average depreciation (based on the number of surgeries performed by using the machineries) rather than to compute a time based depreciation.

[7] Because of this motivation we think that the intensity driver is better than the transaction one.

These *activities* should be given due consideration because they are related to a single surgery so we do not have to pinpoint any *activity driver.*

5.2 Activity driver choice to allocate costs to cost objects.

Activity *driver* choice has followed the cause and effect rule in indirect cost allocation and Table 6 shows the output in second last column.

Table 5 Activity drivers and cost

CODE	ACTIVITY	ACTIVITY COST*	ACTIVITY DRIVER	ACTIVITY DRIVER TYPOLOGY
GD 1	Nursing critical patients	2,434,656	Number of days per average number of critical patients patients per day	Intensity driver
GD 2	Nursing non critical patients	3,651,985	Number of days per average number of non critical patients patients per day	Intensity driver
REP 5	Internal logistics	110,481	Number of internal orders	Transaction driver
REP 10	Consumable resource and instrument management	1,104,812	Number of orders	Transaction driver
REP 7	Department cleaning	753,600	Squared metres	Transaction driver
REP 8	Contentious procedures for health activities and assurance	148,225	Efforts in percentage	Intensity driver
REP 6	Department machinery maintenance	261,148	Efforts in percentage	Intensity driver
REP 11	medical department monitoring	3,795,742	Number of sheets weighted for number of beds	Intensity driver
REP 9	Law activities for the department	274,156	Number of beds	Transaction driver
INT 1	Operating room use	710,684	Surgery duration	Duration driver
P2	SDO registration	48,669	LHA surgery	Transaction driver
P1	Hospital admission	238,569	LHA hospitalizations	Transaction driver
P3	Department admission	108,635	Department hospitalizations	Transaction driver

* Year 2004: yearly values

To make an example, the activity "Internal logistics" (REP 5) deals with the management of departmentrequests sent to the storehouse: the driver we have chosen is the number of *internal requests* which the department sends. The activity "Instruments and materials requests management" (REP 10) deals with material purchasing by the departments: the activity driver we have chosen is the *number of purchasing orders* made. Activity "healthcare monitoring" (REP 11) which deals with the control of hygiene rules has a driver which considers both the number of forms that inspectors *compile* when they carry out controls and the number of beds of the inspected department, in fact this last element could influence the amount of effort in the activity development.

In several cases we were not able to be *highly* accurate because of the paucity of available information.

5.3 Cost of objects and costof configurations

The cost *estimation* of identified cost objects needs to consider three elements:

Activity cost portions attributed to the objects by using activity drivers
Cost of activity directly attributed to surgery intervention
Cost aggregation directly attributed to specific cost objects

Activity cost portions attributed to the objects by using activity drivers

In this category we obtained the *activity-costing rate* (activity unitary cost) by dividing the total cost of the activity by the activity driver amount. Then we calculated the cost allocated to the object multiplying the *activity costing rate* by the activity driver amount of the specific object

For example the *activity driver* for the department of the activity " Internal logistics" is the number of internal orders, so if we want to get the portion of activity cost related to a department we should simply multiply the activity costing rate by the number of internal orders requested by that department. Then this activity is attributed to the cost object " Indirect costs" by using the driver " number of department hospitalization". This driver allows us to identify the unitary cost related to a single hospitalization: in this case we can follow the process that we have already described.

Cost of activities which are directly attributed to surgery intervention

Each activity cost calculated directly (described in the previous paragraph) is completely attributed to the cost object "surgery" because it is entirely related to it.

Cost aggregation directly attributed to specific cost objects

Some items are a cost aggregation of several resources. Our model considers the following items:

- *Medical aftercare* (which is related to the cost object "daily hospitalization)
- *Meals* (which are related to the cost object "daily hospitalization)
- *Laundry service for hospitalization* (which is related to the cost object "daily hospitalization)
- *Laundry service for surgery* (which is related to the cost object "surgery")
- *Sterilization for surgery* (which is related to the cost object "surgery")

The ABC methodology application, based on the described model, has allowed us to calculate cost of the following objects:

Table 6 The cost of Cost objects

COST OBJECTS	**€ (*)**	
PATIENT		***52.00***
SDO registration	3.00	
Admission to Hospital	9.00	
Admission to department	40.00	
SURGERY		***2,540.00***
Surgery room use	90.00	
Anaesthesia Preparation, Monitoring and Assistance	811.00	
Preparation of surgery area	8.00	
Surgery development	1,445.00	
Patient transfer	22.00	
Instruments preparation	2.00	
Patient location	0.50	
Patient preparation (for surgery)	2.50	
Patient transfer to surgery room	21.00	
Surgery room preparation	4.00	
Surgery programming	20.00	
Sterilization for surgery	42.00	
Lab tests and physician's visit	62.00	
Laundry service for surgery	10.00	
DAILY HOSPITALIZATION FOR CRITICAL PATIENTS		***295.00***
Nursing	277.00	
Medical aftercare	14.00	
Meal	2.00	
Laundry service for hospitalization	2.00	

*Year 2004: yearly values

Moreover we have calculated the cost of indirect activities that go to the upkeep of the department : it is estimated as € 283.00. Furthermore the following table shows the cost configurations we have already described.

Table 8 The value of cost configuration

COST CONFIGURATION		
COST FOR TAKING OVER PATIENT		***52.00***
SDO registration	*3.00*	
Admission to hospital	*9.00*	
Admission to department	*40.00*	
IN PATIENT COST (**)		***642.00***
Cost of patient while in department	52.00	
Meal (2 days)	4.00	
Nursing (2 days)	554.00	
Medical aftercare (2 days)	28.00	
Laundry service for hospitalisation (2 days)	4.00	

FULL COST OF PATIENT		***747.00***
In-patient cost	642.00	
Department upkeep indirect costs	105.00	

AFTER SURGERY PATIENT COST			***3,182.00***
In-patient cost		642.00	
Surgery		2,540.00	
Surgery room use	*90.00*		
Anaesthesia Preparation and Monitoring and Assistance	*811.00*		
Preparation of surgery area	*8.00*		
Surgery development	*1.445.00*		
Patient transfer	*22.00*		
Instruments preparation	*2.00*		
Patient location	*0.50*		
Patient preparation (for surgery)	*2.50*		
Patient transfer to surgery room	*21.00*		
Surgery room preparation	*4.00*		
Surgery programming	*20.00*		
Sterilization for surgery	*42.00*		
Lab tests and physician's visits	*62.00*		
Laundry service for surgery	*10.00*		

FULL COST OF OPERATED PATIENT		***3.287.00***
After surgery patient cost	3.182.00	
Indirect costs for upkeep of department	105.00	

*Year 2004: yearly values
** For laparoscopic cholecystitis treatment, two hospitalization days are considered

The cost configuration "Full cost of operated patient" includes costs related to the department where a patient is hosted and operated.

Surgery cost (surgery process cost, surgery indirect cost and surgery room cost) is strongly influenced by disposable laparoscopic instruments and by anaesthesia.

The full cost of the operated patient can be a good cost figure, which we can however compare with related DRG's. For example the DRG cholecystitis treatment (for year 2004) is € 2,721.00. This value is more similar to the simple surgery cost than to the cost of the operated patient (in particular the cost calculated without the structure support cost)

6 Conclusions

This paper illustrated an experimental Activity-Based Costing system for measuring a specific cost object referred to a laparoscopic surgery.

The results show the informative potentials of an ABC system applied in health-care, as well as the importance of an appropriate design for such potentials to be properly achieved. In particular, the study of a "hierarchy of activities" which may appropriately reflect the flow of activities for a given cost object turns out to be extremely important for a proper selection of the drivers and the building of appropriate cost configurations. Such cost configurations can be useful for different goals at different decision -making levels within the system: the overall cost of the operated patient can be decisive for taking decisions about the price policies on a regional scale, while an in-depth analysis of the cost of the surgical operation can turn out to be important, department -wise and business-wise, to implement activity management policies aimed at maximising cost effectiveness. On the other hand, the example also shows the importance of an adequate use of the information existing in the cost accounting systems used by the health -care facilities, which results in the implementation of ABC systems which are in fact “hybrid” costing systems.

Finally, some recent studies on the importance of cost information for the health professionals can spur further reflections on the role that advanced cost management systems can play for hospitals and the health-care industry. In an international comparative study, Jacobs, Marcon and Witt (2004) showed that clinical professionals (especially in Italy) are sensitive to and interested in cost and performance information, even if the level of access to such information is not always adequate, and such information is perceived as inadequate since it has been designed for responding to corporate and regulatory organisational requirements rather than for supporting clinical performance. Another study (Pizzini 2006) proved that health-care managers are convinced that the usefulness of cost information is directly proportional to the available level of detail, and that, if so managed, it can help professionals to improve their performance. In particular, it could be extremely useful to focus attention on the process itself and on its sub-processes, since only the awareness resulting from an in-depth analysis of how inputs are converted into outputs can enable the health -care managers to gain an insight of the ‘black box’ of internal operations and, as a consequence, to cho ose the most appropriate paths towards the improvement of their actual *performance*.

The results of such studies highlight the importanceof designing and implementing refined costing systems in health-care, not only to assess the economic effect of new techiques and technologies, but alsoto increase the effectiveness of control systems into health care units and regional systems.

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